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Martin L. H. Thomas[1], Jo-Anne Stevens[1],
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ABSTRACT

This publication incorporates an association map of terrestrial, littoral and sublittoral areas of Pendleton Island, New Brunswick, an island of 117ha lying in the Deer Island Archipelago of the Quoddy Region of the Bay of Fundy. Terrestrial areas were surveyed using large quadrats, littoral areas by means of belt transects and subtidal areas by belt transects recorded on video tape. Twenty seven associations have been recognised but some cover only very limited areas. The bulk of the land area is comprised of a mixed forest typical of the coastal forest of the area. Much of the remaining area is oldfield (2 types) and alder thicket which are successional seres from old pasture and cultivated land. There is also an exposed headland association of significant size and a unique small beach-bar system. Eight littoral associations are present in the very extensive shore area consequent upon the high tidal range, three reflecting the general littoral zonation pattern. There are two lichen dominated zones in the supralittoral zone and fringe and a broad *Ascophyllum nodosum-Fucus* association which characterises the midlittoral over most of the island. In parts of Pendleton Passage extensive shore areas are occupied by mussel beds. The remaining intertidal associations occupy only limited areas. The fourteen subtidal associations reflect the extraordinary diversity of marine life around the island correlated with the high velocity tidal currents and the resulting high food supply for filter feeders. Overall, the subtidal hard-bottom associations reflect the intense grazing pressure by the green sea urchin, *Strongylocentrotus droebachiensis,* combined with the high current which excludes this species from some locations. Moderate currents on hard bottoms generally support a crustose coralline algal association, characterised by crustose algae and low species richness in any one location. Taken as a whole, however, this association is one of very high overall diversity. Several other associations are variants of the crustose coralline algal association. In moderate currents, where urchins are sparse, associations dominated by ascidians, the sea cucumber *Cucumaria frondosa,* red algae or the brown alga *Desmarestia viridis* are found in various locations. In the strongest currents the most common dominant is the brown alga *Agarum cribrosum* associated with and sometimes replaced by the horse mussel *Modiolus modiolus. Mytilus edulis*, the blue mussel also dominates limited high current areas. In lower current velocities, where hard bottoms grade into sediments of sand and mud, associations dominated by the sand dollar *Echinarachnius parma* or the worm *Myxicola infundibulum* are common.

RÉSUMÉ

Cette publication contient une carte des communautés des zones terrestres, littorales et infralittorales de l'île Pendleton, au Nouveau-Brunswick, une île de 177 ha s'étendant dans l'archipel de Deer Island, dans la région Quoddy de la baie de Fundy. Les zones terrestres ont été explorées en utilisant de grands quadrats, les zones littorales au moyen de bandes transects et les zones infratidales au moyen de bandes transects prises sur bandes vidéo. Vingt-sept communautés ont été identifiées mais certaines ne couvrent que des territoires très limités. La majeure partie des zones terrestres est composée de forêts mixtes, typiques des forêts cotières de la région. Une bonne partie des autres zones terrestres est constituée de vieux champs (2 catégories) et d'aulnaies résultant d'une succession de végétation dans de vieux paturages et de vieilles terres cultivées. Il existe aussi une communauté assez importante vivant à découvert sur des promontoires et un étonnant petit système sur une barre de sable et de gravier. Huit communautés du littoral se trouvent dans la zone profonde formée par la grande portée des marées, trois reflétant la norme générale de zonage du littoral. Celles-ci comprennent deux zones où prime le lichen dans la zone supralittorale et en bordure et une vaste communauté d'*Ascophyllum nodosum-Fucus* qui caractérise la zone médio-littorale dans presque toute l'île. Dans certaines parties du Passage de Pendleton, de grandes surfaces du littoral sont occupées par des bancs de moules. Le reste des communautés intertidales n'occupent que des espaces limités. Les quatorze communautés infratidales reflètent l'extraordinaire diversité de la vie marine autour de l'île, une vie qui dépend des courants des marées de haute vélocité qui apportent une nourriture abondante aux animaux filtreurs. En général, les communautés infratidales qui se trouvent sur les roches reflètent l'intense pression exercée par l'alimentation des oursins communs, *Strongylocentrotus droebachiensis*, en même temps que le type de courant qui exclue cette espèce des territoires balayés par les très forts courants. Les courants modérés sur les fonds rocheux font habituellement vivre une communauté d'algues coralliennes crustacées caractérisée par la présence de ces mêmes algues et une faible diversité d'espèces dans un seul et même lieu. Pris dans son ensemble, toutefois, cette communauté en est une d'une très grande diversité. Plusieurs autres communautés sont des variantes de la communauté d'algues coralliennes crustacées. Dans les courants modérés où les oursins sont clairsemés, on trouve à différents endroits des communautés dominées par les ascidiens, le concombre de mer *Cucumaria frondosa*, les algues rouges ou l'algue brune *Desmarestia viridis*. Là où les courants sont les plus forts, la prédominance revient à l'algue brune *Agarum cribrosum* associée à et parfois remplacée par la Grande moule du Nord *Modiolus modiolus*. *Mytilus edulis*, la Moule bleue, domine également des zones restreintes balayées par les hauts courants. Dans les courants de basses vélocités, où les fonds rocheux entrent dans les sédiments de sable et de boue, des communautés dominées par le Petit clypéaster *Echinarachnius parma* ou par le ver *Myxicola infundibulum* sont communes.

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We are indebted to many people who have assisted in this project. Transportation to the island and assistance with subtidal transects and general diving services were provided by Capt. R. Bosien of the University of New Brunswick research vessel "Mary O". Summer student assistants Tom. Raithby, Margo Chase, Shawn Kneeland, Greg. Bacon and Erin Walsh helped at various times. Hal. Hinds of the Connell Herbarium, University of New Brunswick, assisted with the identification of the plants. Wilfred Morris assisted with the figures and with Sonja Clarke expertly drew the base map and all the overlays required for colour printing. Julie Morris patiently prepared the hand coloured copies of the map for the referees. This project was supported by a Natural Sciences and Engineering Research Council of Canada Operating Grant (# A6389) to M.L.H.T., by a University of New Brunswick Research Grant #21-37 to M.L.H.T. and by the Natural Sciences Division, New Brunswick Museum.

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INTRODUCTION

Pendleton Island, lying in New Brunswick at 45° 02' N and 67° 56' W, is part of the Deer Island Archipelago (Western Isles) which separates Passamaquoddy Bay from the southwest part of the Bay of Fundy proper (Fig.1.). The island itself (Fig. 2), lies off the northwest tip of Deer Island and is approximately 2.27 km long by 0.9 km wide. Figure 2 illustrates the topography; the highest point is Monument Hill lying at 75m above mean sea level. For the most part the island consists of gently undulating terrain with a few rocky outcrops inland. There are no ponds but a few areas are slightly swampy. There is only one permanent stream, rising at a spring in the southern old field and discharging into Pendleton Passage. The coast along the SE shore has mostly low rocky cliffs giving way to shores of very varied nature ranging from rock to mud. The NW coast and northern tip on the other hand is characterised by precipitous cliffs up to 10m high and mainly rocky shores. Opposite the narrowest part of the island, on the NW shore, is a bay with a steep, high energy, gravel barrier beach which cuts off a small lagoon which drains completely at low tide.

Pendleton Island is separated from Deer Island by the narrow, shallow Pendleton Passage and from McMaster Island to the northeast by Little Letite Passage. In consequence of the high tidal range in the area, extremely rapid tidal currents run through these passages creating unique marine habitats.

History. Prior to its colonisation by white settlers, Pendleton Island was used by Micmac Indians at least seasonally. Evidence for this is provided by at least two middens, the sites of which are shown in Fig. 3, and by Indian artifacts which may be found on the island. The Indian names for the island were "Odcobbahommuck" or "Umkupahumk" (Rayburn 1975). The copious quantities of molluscan shell in the middens suggest that the island was a prime shellfish harvest site.

The first use by white man was probably as an American military post during the Revolutionary War. Raymond (1892, 1893) records that the island was held in command by Captain J. Prebble in 1780, at which time it was known as Little Letite Island. Settlement occurred shortly after this, the first occupant being Thomas Doyle. It was sold to Thomas Pendleton in 1796 and was henceforth known as Pendleton Island. Several generations of the Pendleton family occupied the island, clearing 40-50 acres, occupying two homestead sites, raising various crops and grazing cattle until about 1935. A family graveyard remains on the southern homestead. Since it was abandoned, the northern homestead has been completely grown over by alders, while the southern one still has several acres of meadow, probably maintained through springtime burning by the local, mainland inhabitants.

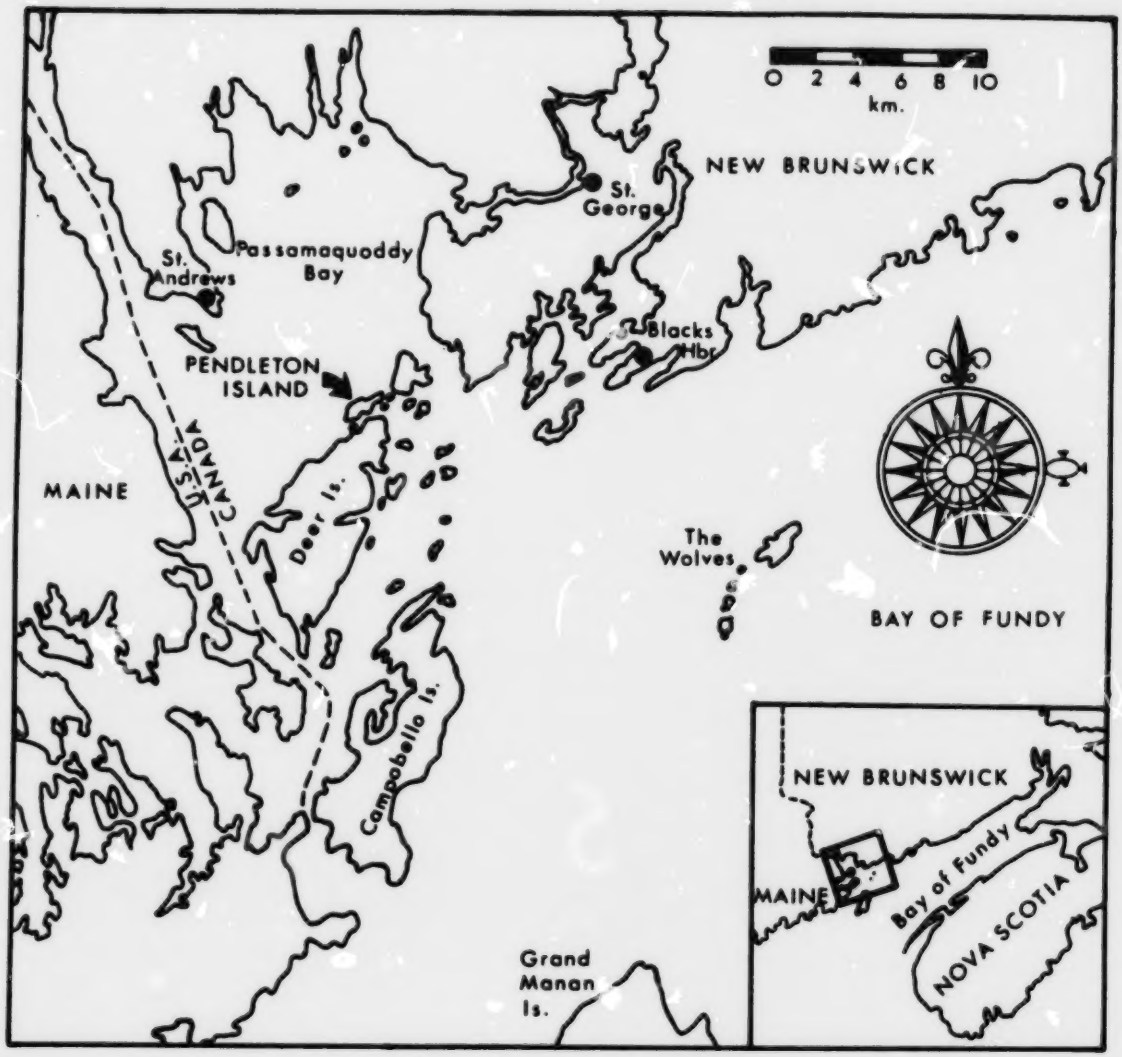

Figure 1. The arrow shows the position of Pendleton island in the Deer Island Archipelago, New Brunswick. The inset shows the location of the Quoddy Region within the Maritimes.

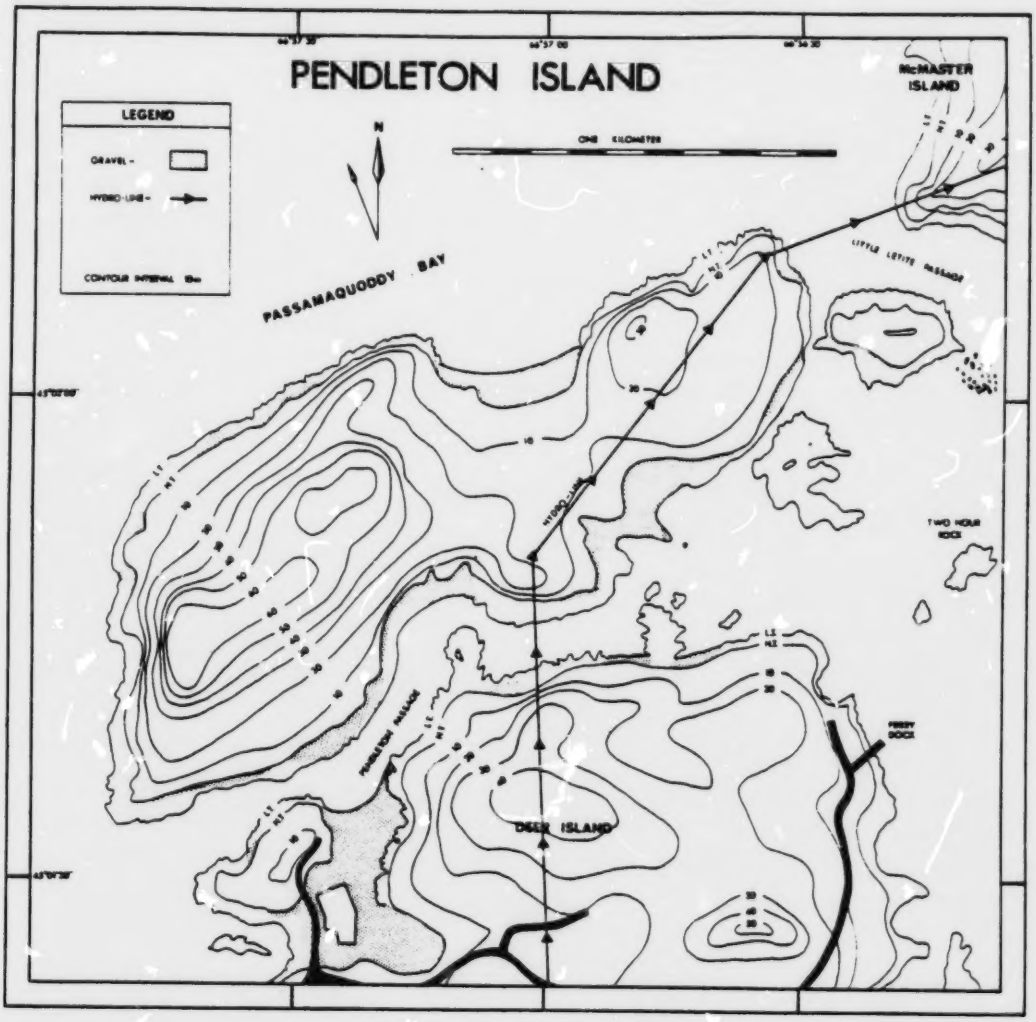

Fig. 2. Topographic map of Pendleton Island. Contour lines are in m.

The University of New Brunswick leased the island from the Pendleton family in 1986 and maintains it as a multidisciplinary research and teaching facility. No alterations have been made and access is controlled.

Climatic and Oceanographic Setting. The climate of the Quoddy Isles is generally similar to that of the coastal Bay of Fundy but has local modifications (Thomas 1983a). The general weather of the region is controlled by two air masses, the continental air mass moving from the west and the Atlantic air mass moving in from the ocean, either of which may dominate the weather. The characteristics of these two air masses are very different and in consequence the weather is extremely variable, with wide ranges in temperature, humidity, wind, etc., from day to day and season to season. The variability is perhaps best demonstrated by temperature ranges which may exceed 20°C in a single day. Local effects include fog, which is frequent in spring and summer, maintaining cooler temperatures than inland, and relatively mild winters. In winter, prevailing winds are from the W and NW, while in summer SW winds predominate. At any season, wind shifts to the NE or SE are frequent and usually associated with precipitation. As a consequence of the high tidal range and intense mixing of the water mass, the formation of sea ice is negligible.

Oceanographic conditions in the Passamaquoddy Bay area have been summarised by Trites and Garrett (1983). The most striking feature is the very high tidal range. In the Pendleton Island area, the mean range is 5.5m with the mean spring tide range reaching 6.6m (Thomas *et al.* 1983). The effects of this are varied but the most obvious is the striking difference in the appearance of the shoreline at high and low tide. Where the gradient of the shore is gentle, very large areas are exposed by the tide. The area of Pendleton Island at high tide is 117.6ha while at low tide it is 151.5ha, a 29% increase! A second obvious effect is the very rapid tidal currents that run through narrow passages such as Little Letite Passage and Pendleton Passage. Average surface currents in Little Letite Passage 3h before and after high tide time average about 1.3m s^{-1} (Trites and Garrett 1983). At places in Pendleton Passage they are much higher. Bottom currents in Pendleton Passage have been recorded up to 0.7 m s^{-1}. These currents are extremely fast for marine waters and present some hazard to navigation when they are at a maximum. In Pendleton Passage the combination of shallow depths and rapid tidal currents makes navigation difficult other than at high tide slack water.

Sea water temperatures in the Pendleton Island area are greatly affected by tidal mixing which prevents the formation of a thermocline in summer, thus keeping surface waters cool. Conversely, in winter this mixing prevents the occurrence of very cold surface temperatures and precludes the formation of sea ice. Mean sea surface temperatures around Pendleton Island average 2.5°C in February, 7°C in May, 11.5°C in August and 8°C in November. For equivalent times, sea surface salinities average 31.5,

30, 31.5 and 32 °/₀₀ (Trites and Garrett 1983) again reflecting the vigorous tidal mixing; the spring salinity minimum results from increased land run-off on the spring freshet, principally from the Saint John river, carried toward the mouth of the Bay of Fundy by the residual counterclockwise current, part of the Labrador Current. Fig. 3 shows sea surface temperatures monitored in Pendleton Passage during 1989. Also on the figure are maximum and minimum intertidal temperatures which reflect the variability of the intertidal zone, subject to both water and air temperatures. The range is at times extreme, illustrating the conditions to which intertidal organisms must adapt.

No part of Pendleton Island is exposed to the full force of ocean waves. The most exposed shore is that facing NW into Passamaquoddy Bay where the fetch is about 10km. It is doubtful that waves over 1m in amplitude ever reach the shore except during very violent storms. The SE facing shore of Pendleton Island along Pendleton Passage is exceedingly sheltered for a fully marine situation; waves in the Passage are of negligible height.

Geology, Marine Sediments and Soils. The geology of Pendleton Island is illustrated in Fig. 4 (Patel *et al.* 1987). The island is divided into two distinct geological zones. The NW portion of the widest part of the island consists of conglomerate sandstone of the Devonian age Perry Formation with minor lava flows and dykes. The remainder of the island is of Silurian age, and consists mainly of rhyolite tuff with associated ignimbrite and basic intrusives. The two zones are separated by a fault, clearly visible where it strikes the shoreline.

Intertidal and marine rock and sedimentary substrates up to about 10m depth, are shown in Fig. 5. This figure does not show the rock type since details are obscured by the normally complete cover of biota. However, the trends shown in Fig. 4 can be expected to continue close to shore.

The soils consist mainly of Lomond gravelly loam (Wicklund and Langmaid 1953) which is a thin, gravelly, brown loam generally unsuited to cultivation but adequate for grazing land.

General Ecology. A. Marine. The marine ecology of the Passamaquoddy Bay area has been described in Thomas (1983). The area supports a rich marine biota which has affinities to several biogeographic units. The cold waters of the Labrador Current dominate the system and bring larvae, propagules, etc., as well as adults of northern species. The biota is therefore basically boreal. However, there is also a significant influx of water from the Gulf of Maine, containing species of more southern affinities. At times, water masses from the Gulf Stream become entrained in coastal waters and may enter the bay, bringing sub-tropical biota. The net result is a more varied biota than might be expected, with both southern and northern limits of many species occurring in the area.

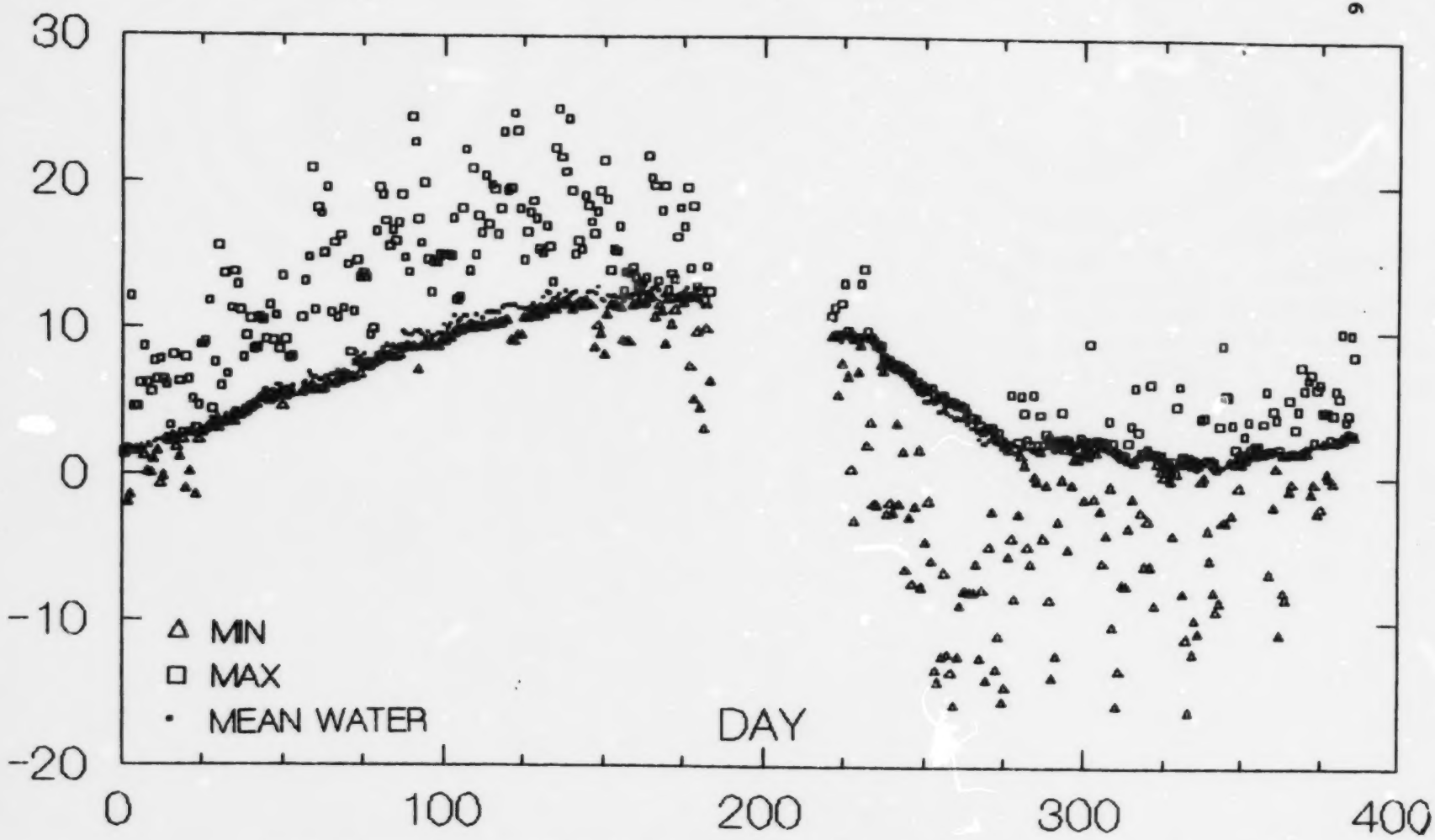

Fig. 3. Temperatures (°C) recorded in the lower midlittoral zone of Pendleton Passage, from April 1, 1989 to April 21, 1990. The mean water temperature is taken from readings with the sensor immersed; the min. and max. cover both submersion and emersion

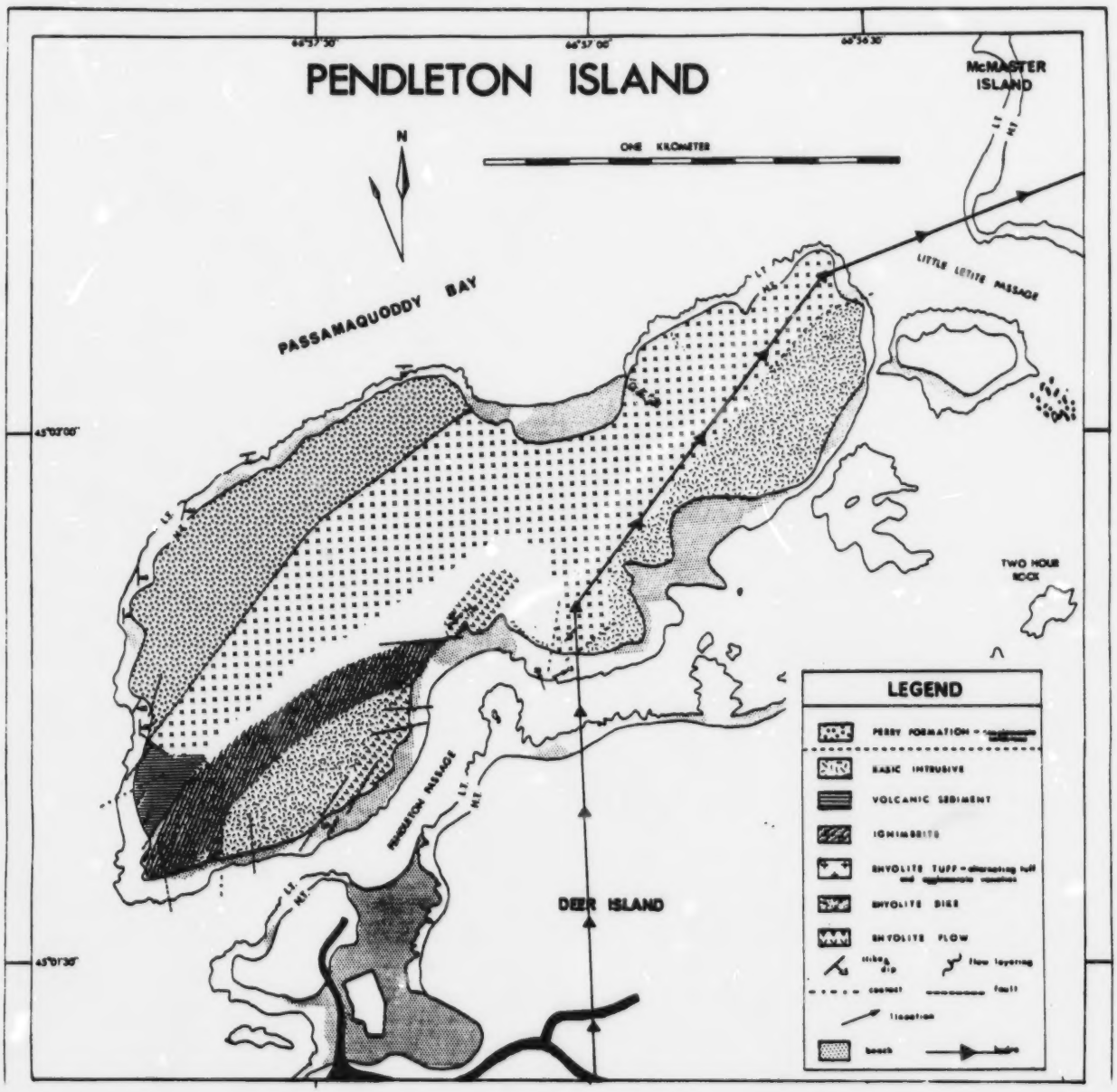

Fig. 4. Geological Map of Pendleton Island (Patel, Hunter and McCavour, 1987)

At the same time, the productivity of the area is higher than in adjacent waters, a consequence of the vigorous tidal mixing, which brings nutrient-rich sub-surface waters to the top. This in turn promotes good phytoplankton production (Laksminarayana 1983) followed by high numbers of zooplankton (Corey 1983, Roff 1983). Fisheries in the area are varied and economically important, major components being herring, lobsters, scallops and groundfish (Wilder *et al.* 1974); recently the aquaculture of Atlantic Salmon has become very important (Cook 1988). Fish of the area are described by Scott (1983). The Western Isles are also noted for large populations of marine mammals, particularly fin and humpback whales which congregate for feeding in late summer (Gaskin 1983). The concentrations of food which attract many of the marine mammals are also responsible for large aggregations of seabirds, particularly phalaropes, gulls and eiders. Birds of the area are discussed in Christie (1983).

Benthic associations occurring from high tide level to the deepest locations differ according to the character of the bottom. Hard bottoms, characteristic of high energy environments, such as much of the intertidal and locations with rapid bottom currents, harbour a rich and diverse biota with high biomass. Intertidal rocky shore communities have been described by Thomas (1983, 1990) and are characterised by a wide midlittoral zone dominated by the knotted wrack *Ascophyllum nodosum.* This species is abundant even in extreme exposure and creates a dense canopy within and under which occur a wide variety of animals and plants. Above the midlittoral, the supralittoral fringe is dominated by *Fucus spiralis* and the rough periwinkle *Littorina saxatilis*. At the bottom of the shore a narrow infralittoral fringe supports a diverse biota in which the most characteristic species are *Fucus edentatus, Spongomorpha arcta* and *Mastocarpus stellata* and *Chondrus crispus*. Below low tide, the character of the association changes abruptly, mainly due to the influence of the green sea urchin *Strongylocentrotus droebachiensis*, which occurs in very large populations, grazing almost all except encrusting coralline algae and leaving an 'urchin barren ground' of very low biomass, except where current velocities are high. Typical members of this association, in addition to the crustose algae and urchins, are limpets (*Colisella testudinalis*) and several species of chitons. In areas where current velocities are higher, hard bottom associations become rich and varied, supporting large concentrations of sea cucumbers (*Cucumaria frondosa*), several species of anemone (notably *Metridium senile* and *Tealia felina*), ascidians such as *Halocynthia pyriformis* and *Boltenia ovifera* and in many areas extensive patches of the horse mussel, *Modiolus modiolus*. Logan *et al.* (1983) discuss these communities in detail and more information is available in Logan *et al.* (1984) and Logan (1988).

Soft bottom communities vary according to the substrate, those of sediments containing mud being more diverse than those of sand. Steele (1983) has described the fauna of coarse sedimentary shores while Wildish (1983) examined subtidal sedimentary substrates. Intertidal sandy areas support small populations of fauna, mostly crustaceans, while more muddy locations are dominated by pelecypods such as the soft-shell clam

Mya arenaria and polychaetes, mainly *Nereis virens*, *Nephtys* spp. and *Glycera* spp. Subtidally, both mud and sand bottoms support a wider diversity of species, among which polychaetes, molluscs and crustacea are most frequent.

B. Coastal terrestrial. The coastal forest of the Passamaquoddy Bay area forms part of the submaritime fringe and has been described by Hinds (1983). On a wider basis, the forests of the Fundy region have been described by Loucks (1960) and Rowe (1972). The characteristic components of the coastal forest in the Quoddy Region are red spruce (*Picea rubens*), generally the dominant tree, accompanied by yellow birch (*Betula alleghaniensis*), mountain ash (*Sorbus americana*) and red maple (*Acer rubrum*). The immediate shoreline is composed of a mixed forest of white spruce (*Picea glauca*), black spruce (*Picea mariana*), balsam fir (*Abies balsamea*) and tamarack (*Larix laricina*); along very sheltered shores, eastern white cedar (*Thuja occidentalis*) is common.

Birds of the coastal forest were described by Christie (1983) and the amphibians and reptiles by Gorham and Bleakney (1983). McKay (1965) described the vertebrate fauna of the Grand Manan Archipelago in the mouth of the Bay of Fundy.

Objectives of the Project. The main objective of the project was to produce an association map covering all the terrestrial, littoral and sublittoral associations down to at least 10m in depth as a base for further biological work on the island and to provide baseline information against which possible future changes may be assessed. It was also hoped that the production of such a comprehensive work would spur the efforts to create a marine park in the area. To our knowledge this is the first such map for a Canadian location although similar ones are available for locations in other countries. We also hope that the availability of this information will foster further, more varied research in one of the world's unique marine areas.

METHODS

Littoral. During 1986, 21 transects, running at right angles to the shoreline, were run by the method described in Thomas (1989) from low tide level to the top of the supralittoral zone or to 3m up the cliff, where present. These transects were situated up to 400m apart but were much more frequent in more variable areas. The shore profile and the distribution of all species that were recorded along these transects, were used to determine zones of dominance for mapping. In 1987 an additional 48 transects, bringing the total to 69, were run between the others to bring the frequency of transects to not less than 1 per 100m of shoreline. In 1987, a full physical profile was omitted but the gradient for each section of the littoral having reasonably constant slope was determined by means of an Abney Level; the distribution of all common species and zones of dominance were recorded.

Sublittoral. In the summer of 1988, 32 subtidal transects were run at 200m intervals around Pendleton Island using the littoral transect lines as starting points. To mark the transect location, a 12 mm lead cored, polypropylene rope, marked at 5m intervals with a prominent coloured plastic tag and with a 30kg anchor at each end, was laid on the bottom. The seaward end of the line was marked by a 30cm diameter fluorescent marker buoy. Each transect was surveyed by making a continuous colour video recording of the bottom, using a Sony CCD-V3 camera equipped with an Aquavideo WAC-2 wide angle lens in an Aquavideo PV-CCDV3 underwater housing. The image was recorded at the camera. The camera was held vertically such that about 1 linear m of line appeared in each frame. A total area of 1.3m^2 was photographed in each frame. To aid in keeping a constant amount of bottom in view, 1m long x 9mm diameter iron rods, painted yellow with black bands at 10cm intervals were laid at intervals along transect lines to act as a reference. At the 5m tag locations, the photographer paused briefly to make sure the tag was clearly displayed and included a shot of the face of the depth gauge. Occasionally the camera was tilted forward to give a panoramic view or to the side to include biota of particular interest. The speed of swimming was 11.12±2.46 m min^{-1}. The diver was instructed to collect any specimens that were difficult to identify from the video image. The transects extended from mean low tide level to at least 10m depth, in increments of 100m. The longest transect was 300m. The University of New Brunswick R.V. "Mary O" was used as a mother ship for all subtidal work; for shallow locations a Zodiac Mk. II FGT inflatable boat served as a tender. For playback and analysis, a Sony EV-S700U video casette recorder was used with a Sony KV 2064R 532mm monitor. From the tapes the composition and extent of benthic associations was determined together with the bottom type. The association and bottom type data was later transferred to maps.

Terrestrial. Terrestrial plant associations were surveyed during the summer of 1988. Vegetation was sampled in 10, 200m^2 plots the sites of which were selected to lie within distinct plant associations as shown on large prints of 1:1200 colour air photographs (DNR 84518-19). Within each plot, 12, 1m^2 quadrats were used to assess percent cover of each herbaceous species. In addition to the plots, three transects were used to determine the floristic components of the association of the gravel barrier beach on the NE side of the island.

Collections. Representative specimens of species from all habitats have been deposited in the collections of the New Brunswick Museum and The University of New Brunswick, Saint John.

RESULTS

Fig. 5 shows the littoral and sublittoral substrates found during this survey.

Fig. 6 (foldout map in rear pocket) shows the extent of each association observed.

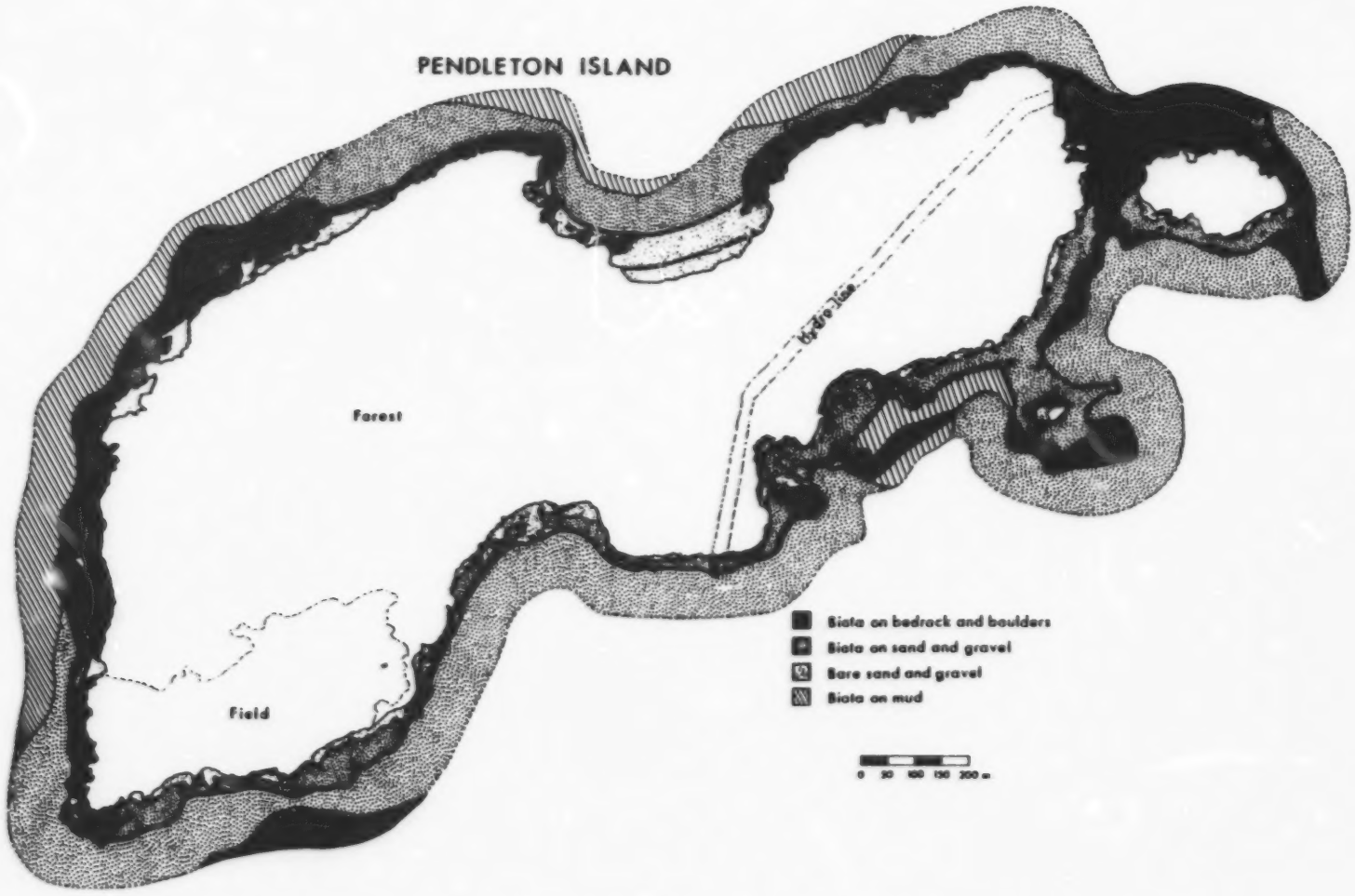

Fig. 5. Littoral and sublittoral substrates of Pendleton Island.

Association Composition. The association descriptions that follow are in the same order as the legend of figure 6.

Abiotic Areas

1) Bare rock, sand and gravel. This category was essentially devoid of macrobiota and occurred in littoral and sublittoral locations where wave action was high or the substrate unstable. In most cases, seasonal colonisation by ephemeral algae such as *Ulothrix flacca* and colonial diatoms took place.

Littoral Associations

2) *Verrucaria maura*. This black encrusting lichen is most typical of the supralittoral fringe, where it normally covers 50-100% of the substrate. Above the fringe *V. maura* declines in cover but may still dominate the sparse association well into the supralittoral zone. *Verrucaria halizoa* and *V. mucosa* are also present at the very bottom of the fringe; at this same level the topmost plants of *Fucus spiralis* normally occur. The green alga *Prasiola stipitata* is occasionally present in small patches. The only animal generally resident is the rough periwinkle, *Littorina saxatilis,* although in foggy weather, the amphipod *Gammarus oceanicus* forages here.

3) Lichens other than *V. maura*. The supralittoral zone is generally colonized either by this association or by #4) following. The lichen association is spotty and variable and does not usually cover more than about 25% of the substrate, except at bird perch sites. The specific composition and intra-zonal stratification of this lichen-dominated association await thorough investigation. Some common species in the lower supralittoral are a *Verrucaria* tentatively identified as *V. ceuthocarpa*, the encrusting orange *Caloplaca scopularis* and *C. verruculifera*, *Arthonia phaeobaea* and *Lecanora contractula.* Among the other common lichens found somewhat higher on the shore are *Parmelia saxatilis, P. sulcata, Xanthoria parietina, X. elegans, Xanthoparmelia conspersa, X. cumberlandia, Phaeophyscia sciastra, Lecanora grantii, L. polytropa, Acarospora molybdina, A. smaragdula, Rhizocarpon grande,* and in damp overhangs, *Lepraria* cf. *finkii*. In sediment-filled cracks and depressions in the bedrock, a sparse association of flowering plants [#4)] is intermixed with this lichen-dominated association.

4) Flowering plants. The flowering plant association is characteristic of the supralittoral zone in areas that are somewhat more sheltered than #3) above and where there is a higher proportion of sediment. The constituents are quite varied but in order of decreasing frequency of occurrence are as follows: *Salicornia europaea, Suaeda maritima, Atriplex patula, Spergularia marina, Plantago maritima, Deschampsia flexuosa, Aster novi-belgii, Ligusticum scothicum* and *Solidago sempervirens.*

On vertical and near-vertical cliffs is another association which does not appear in horizontal mapping, but is nevertheless quite characteristic and extensive. It is dominated

by roseroot, *Sedum rosea*, with scattered *Deschampsia flexuosa* and small *Alnus viridis*.

5) *Enteromorpha-Ulva-Cladophora*. While species in these three genera may co-occur, they do not always do so; however, they tend to be found in rather similar habitats. *Enteromorpha intestinalis* tends to favour habitats in the midlittoral, including tidal pools where there are fresh-water seeps. These instances, however, rarely are large enough to designate as an association. As an association, the most frequent location is at the bottom of the midlittoral zone on coarse sediments or broken rock where the gradient is low and the shore stays quite wet. There, *Ulva lactuca* commonly dominates at lower levels and *Cladophora* sp. at higher ones. This association often occurs in association with association #8), *Mytilus edulis*, described below. *Cladophora* sp. may also occur ephemerally on unstable boulder or coarse gravel beaches, in calm periods in summer.

6) *Ascophyllum nodosum-Fucus*. The midlittoral zone, which on sheltered shores occupies the space between mean high and low tide levels, is termed the fucoid zone. On Fundy shores, in contrast to the situation elsewhere, it also extends to locations of the highest exposure, still colonising the same vertical extent (Thomas 1990). The majority of the midlittoral on Pendleton Island conforms to this pattern and as a result, from a distance, the bulk of the intertidal looks a dull olive-green. This zone is characterised by strong domination by *A. nodosum*, the knotted wrack, which forms a dense, heavy canopy often exceeding 1kg m^{-2} in dry weight biomass. This one species contributes about 90% of the total biomass of the midlittoral. The most common associates of *A. nodosum* are the epiphytic red alga *Polysiphonia lanosa* and three species of the genus *Fucus*. *Fucus spiralis*, forms a very narrow zone just above *A. nodosum* marking the top of the midlittoral zone; the northern barnacle, *Semibalanus balanoides*, also is characteristic of this upper limit. *Fucus vesiculosus*, or bladder wrack, occurs among the *A. nodosum* in patches, particularly on newly exposed substrates or overturned boulders. It is somewhat more abundant in exposed than in sheltered situations. The third *Fucus* is *F. edentatus* which characteristically dominates the lowest part of the midlittoral, below the main body of *A. nodosum*. It is never as abundant as the latter species and is somewhat less constant in occurrence, favouring exposed locations. Very occasionally, in the same sub-zone *Fucus evanescens* occurs, particularly in shelter. Although the fucoids are the characteristic organisms of this zone and give it an overall appearance of uniformity, it is really a broad and diverse area with several distinct sub-zones.

The upper midlittoral is the least diverse, the most typical organisms being *F. spiralis, A. nodosum, S. balanoides* and *Littorina saxatilis*. In the understory the shiny black lichen, *V. halizoa* is confined to this area but is accompanied by the topmost individuals of the red encrusting alga *Hildenbrandia rubra* and the encrusting green lichen *Verrucaria mucosa*. In crevices in the rock, the tiny tubicolous worm, *Fabricia sabella*, is abundant, extending to the lower midlittoral. Having the same range but living almost exclusively near the base of fucoid alga stipes, are the hydroid *Sertularia pumilla* and the bryozoan *Flustrellidra hispida*. On fucoids the smooth periwinkle *Littorina obtusata* is usually abundant and the amphipod *Gammarus oceanicus* abounds in the protection

of the fucoid canopy.

The mid-midlittoral is considerably more diverse than areas above. Several organisms occur there and at lower levels. These include the third of the periwinkles, *Littorina littorea*, the common periwinkle, which extends into the upper midlittoral only in very sheltered locations, and several other molluscs including the tortoiseshell limpet, *Colisella testudinalis*, the dog whelk *Nucella lapillus* and the blue mussel *Mytilus edulis*. Among the new algae appearing here are the reds *Chondrus crispus*, *Mastocarpus stellata* and *Audouinella purpureum*.

In the lower midlittoral zone of the *A. nodosum-Fucus* association, diversity is again increased and the decline of the fucoid canopy toward the bottom allows more space for other species. Instead of the uniform olive-green of levels above, this area tends to be rather a mottled mosaic of red, green and brown. This change in colour reflects the increasing importance of green and red algae. The green *Spongomorpha arcta* is common together with *Monostroma* sp., *Ulva lactuca* and *Cladophora* sp. Red algae that are common and not infrequently dominant are *M. stellata* and *C. crispus*; occurring with them are the tubular red *Devaleraea ramentaceum* and *Dumontia contorta* and dulse *Palmaria palmata*. At the very bottom of the zone, echinoderms, such as the sea stars *Asterias vulgaris, A. forbesii* and *Leptasterias littoralis,* are found with the top few green sea urchins *Strongylocentrotus droebachiensis*. In some locations scattered individuals of the kelps *Alaria esculenta* and *Laminaria saccharina* are found. The horse mussel *Modiolus modiolus*, the waved whelk *Buccinum undatum* and the turban barnacle *Balanus crenatus,* although more typical of sublittoral waters, also occur frequently at this level.

7) Ectocarpus siliculosus. *E. siliculosus,* and the closely related brown filamentous alga *Pilayella littoralis* commonly occur either as epiphytes on fucoid alga throughout the midlittoral or as a discrete association on rock, cobble or boulder in the lower midlittoral. This association is characteristically of low diversity but may support *Littorina littorea* in considerable numbers.

8) Mytilus edulis. *M. edulis* is virtually ubiquitous in the intertidal zone, being present in the *Ascophyllum nodosum-Fucus* association [#6)], described above. There, however, *M. edulis* rarely forms distinct sub-associations, but rather, is scattered among the holdfasts and remains as fairly small individuals. On sedimentary shores of gravel to cobble where current velocities are high, on the other hand, characteristic 'mussel beds' form. In these beds, *M. edulis* is overwhelmingly dominant but supports an associated biota not found elsewhere. Among the mussels are *Gammarus oceanicus, Nucella lapillus* and a few *Semibalanus balanoides*; beneath them in a layer of trapped mud is the burrowing sea cucumber, *Chiridota laevis*. At lower tidal levels, *S. droebachiensis* is frequent, particularly as small individuals. The mussels form a substrate for sparse growths of *Ulva lactuca, Cladophora* sp., *Ectocarpus* sp. and *Enteromorpha intestinalis*. The best developed and most extensive mussel beds are in Pendleton Passage.

9) Semibalanus balanoides. The northern barnacle *S. balanoides* is the intertidal organism used in the North Atlantic area to determine the top of the midlittoral zone, since it is an extremely faithful indicator of this level. However, it is rare that it forms distinct associations in the upper intertidal, even though it is always common there. Below mean tide level, *S. balanoides* is usually rare because it is the preferred prey of *N. lapillus,* the dog whelk, which is generally common. The upper intertidal therefore forms a refuge for this species. Refuges may also occur at lower tidal levels in locations suited to *S. balanoides* but where the dog whelk is absent. Since dog whelks forage under the fucoid canopy [see #6) above], they are rare in the absence of fucoids even at lower levels. Suitable rocky substrates for barnacle settlement, devoid of fucoids, occur on cobble or stony beaches which are seasonally unstable due to wave action. Several such locations are found on the Passamaquoddy Bay side of Pendleton Island. The only other macrobiota of these associations are ephemeral algae such as colonial diatoms, *Ulva lactuca, Monostroma* sp., *Enteromorpha intestinalis*, *Ectocarpus siliculosus* and *Pilayella littoralis*.

Sublittoral Associations

10) *Agarum cribrosum*. *Agarum cribrosum,* or collander weed, a kelp, is occasionally found in lower midlittoral tidal pools but is much more common subtidally where rocky or stony bottoms occur in areas of very high current velocity such as Pendleton Passage and Little Letite Passage. In such locations it may form a dense canopy, usually with abundant *Modiolus modiolus* among the stipes, upon which prey *Buccinum undatum*. Many other species live in the shelter of the canopy including the anemones *Metridium senile* and *Tealia felina*, the slipper limpet *Crepidula fornicata*, the sunstars *Solaster endeca* and *S. papposus*, the *Asterias* species, the bloodstar *Henricia sanguinolenta* and the sea cucumber *Cucumaria frondosa*.

11) *Chorda tomentosa*. This brown alga, commonly known as bootlaces, forms only small associations in the immediate stony sublittoral. Its association is commonly of low diversity and probably reflects somewhat unstable conditions.

12) *Desmarestia viridis*. *Desmarestia viridis* is a large, coarsely filamentous brown alga of considerable interest. The areas in which it occurs are dominated by the green sea urchin *S. droebachiensis* which creates the 'urchin barren ground' by grazing off the macroalgae, leaving only encrusting red algae such as *Lithothamnion* sp., *Hildenbrandia rubra* and the tetrasporic phase of *Mastocarpus stellatus* (formerly referred to as *Petrocelis middendorfii*). *D. viridis*, however, is not grazed since it has the capacity to excrete sulphuric acid. This association occurs in patches in the crustose coralline alga [#14)] and *S. droebachiensis* [#20)] associations described below.

13) Red Algae. The red alga association is really several small associations of basically similar character, but which may be dominated by various members of the Rhodophyta. *Phycodrys rubens* is probably the most common red alga here but *Polysiphonia*

urceolata, Porphyra umbilicalis, Palmaria palmata and *Mastocarpus stellatus* (tetrasporophyte) are also common, alone or in mixed associations. The associated fauna of this association is extremely diverse and includes all those species recorded above in the *Agarum cribrosum* association [#10)] as well as *Mya arenaria* and the hermit crabs *Pagurus* spp.

14) Crustose coralline algae. This association is really an 'urchin barren ground' which has been mentioned above under association #12 (*Desmarestia viridis*). Normally this association co-occurs with *S. droebachiensis*, but sometimes, presumably due to the mobility of the latter species, is almost clear of urchins. There are virtually no macroalgae and the assemblage is low in biomass but high in species richness. Characteristic species are the green sea urchin, *S. droebachiensis,* the limpet *C. testudinalis*, the chitons *Lepidopleurus cancellatus, Tonicella marmorea* and *T. rubra*, several *Lithothamnion* and *Phymatolithon* spp. and *Mastocarpus stellatus* (tetrasporophyte). Other species found in this association include the sponges *Haliclona oculata, Halichondria panicea* and *H. bowerbankii*, the hydroids *Tubularia* sp., *Obelia* sp. and *Antenularia* sp., the alcyonarian *Gersemia rubiformis*, the anemones *M. senile* and *T. felina*, the whelks *B. undatum* and *Neptunea decemcostata*, the nudibranchs *Dendronotus frondosus*, *Coryphella* sp., *Aeolidia papillosa, Acanthodoris pilosa* and *Onchidoris* sp., the bivalves *M. modiolus, M. edulis, Anomia simplex* and *Hiatella arctica*, the polychaetes *Myxicola infundibulum*, *Spirorbis borealis, Spirorbis spirillum* and *Amphitrite johnstoni*, the barnacle *Balanus balanus*, the shrimp *Pandalus montagui,* the lobster *Homarus americanus*, the crabs *Pagurus* sp., *Hyas* sp., *Cancer* sp. and *Carcinas maenas*, the sea cucumbers *Psolus fabricii* and *C. frondosa*, the sea stars *S. endeca, S. papposus, A. vulgaris, A. forbesii* and *H. sanguinolenta* and the ascidians *Boltenia ovifera, B. echinata* and *H. pyriformis*. The algae *D. viridis, L. saccharina, A. cribrosum* and *P. rubens* are scattered throughout the association but in very small quantity.

15) *Myxicola infundibulum*. This association, low in diversity, occupies a habitat in the interface between subtidal rocky and muddy substrates at moderate depths. The species occurs in cracks in rock or in sediment mixed with rock.

16) *Littorina littorea*. This species is typically intertidal and part of the *A. nodosum-Fucus* association [#6)] described above. Occasionally, in the immediate subtidal, down to about 1m depth, large concentrations of the species occur, usually browsing on ephemeral green algae.

17) *Mya arenaria*. The soft-shell clam is typically known for intertidal populations in mud flats. Such 'clam beds' do not occur on Pendleton Island but there are limited subtidal populations in shallow water in pockets of muddy sand. There are few associated species but the predatory gastropods *Lunatia heros* and *L. triseriata* occur along with the polychaetes *Nereis virens, Nephtys incisa, Nephtys bucera* and *Glycera americana*.

18) *Modiolus modiolus*. The occurrence of this species in association with the *A.*

cribrosum association [#10)] has been discussed above. In areas with more moderate currents the species occurs with no or few *A. cribrosum*, but dominating an otherwise similar, diverse association.

19) Asterias. *A. vulgaris* and *A. forbesii* co-occur in most of the subtidal associations discussed here. They are predators feeding principally on bivalve mollusca and are therefore unlikely to dominate an association. However, in places in Little Letite Passage, where currents seem to deposit dislodged mussels, very large concentrations of these species occur. The substrate in these locations consists mainly of blue mussel (*M. edulis*) shells and there are no associated species in these unstable conditions.

20) *Strongylocentrotus droebachiensis*. The green sea urchin is perhaps the most common animal in the shallow subtidal around Pendleton Island. It occurs in many of the associations and the effects of its grazing have been discussed above in relation to both the *Desmarestia viridis* association [#12)]and the crustose coralline algal association [#14)]. It is probably the most powerful influence on subtidal hard-bottom associations in the area. It is, however, not well adapted to high current situations where its globose test makes it vulnerable to dislodgement. In areas of moderate currents the species reaches very high abundance levels and often dominates the association. The associated species are as for the crustose coralline algal association [#14)]. At lower depths, on all types of bottom, the green sea urchin is usually the only epibenthic species present in any number.

21) *Echinarachnius parma*. *E. parma*, the sand dollar, dominates an association of low epibenthic diversity found on muddy sand bottoms along the NW side of Pendleton Island. Apart from a few *S. droebachiensis*, and sparse giant scallops, *Placopecten magellanicus*, there are few resident species of macrofauna. Probably considerable infauna not visible in the video record are present.

22) *Cucumaria frondosa*. This species, the common sea cucumber, has been cited as a frequent member of the *Agarum cribrosum* [#10)], *Desmarestia viridis* [#12)], Red Algae [#13)] and Crustose Coralline Algae [#14)], associations described above. It is indeed a very common member of many of the hard subtidal substrate associations around Pendleton Island. In overall numbers it is probably second to *S. droebachiensis*. In many localities, particularly around the NE tip of Pendleton Island, it becomes a dominant species. A wide variety of species listed above for these other related associations occur with it.

23) Ascidians. Ascidians are more commonly members of other associations than dominants in their own right. However, in some areas of Letite Passage the sea potato *Boltenia ovifera* dominates quite large areas and is present in immense numbers. Panoramic shots of the bottom show closely spaced individuals waving in the current. This seems to be a unique association, not described elsewhere and worthy of further study. In other locations where currents are less severe, another ascidian, the sea peach,

Halocynthia pyriformis, dominates an association on similar hard bottoms. The associated species are those of the crustose coralline algal association [#14)].

Terrestrial Associations

24) Mixed Forest. The mixed forest association dominates the terrestrial vegetation over the majority of the island area. The most important tree species as determined in plot analysis and by visual inspection are *Picea rubens, P. glauca, Abies balsamea, Betula papyrifera* and *Populus tremuloides*. Less common forest trees are *Sorbus americana, Alnus viridis* ssp. *crispa* and *Prunus virginiana*.

The most important vascular plants of the understory are *Cornus canadensis, Maianthemum canadense, Deschampsia flexuosa, Aster acuminatus, A. umbellatus, Trientalis borealis, Achillea millefolium, Viola macloskeyi* and *V. incognita*. 'Feather' mosses are common in intense shade and the few rocky outcrops are dominated by *Cladonia* lichens. At the forest edge, close to the cliff top, the trees thin out and species such as *Empetrum nigrum, Vaccinium vitis-idaea, V. myrtilloides, Juniperus communis, Sedum rosea* and *Campanula rotundifolia* are common, particularly on small promontories.

Along the ridge of the island, particularly in the SW, extensive blow-downs of the dominant trees have occurred; in these areas the ground cover is dominated by a dense, nearly impenetrable growth of raspberry, *Rubus strigosus*. Among the raspberry tangles, *Carex deflexa, Aralia nudicaulis, Dryopteris intermedia, Lycopodium clavatum, L. obscurum* and *Solidago rugosa* are common.

A power line runs through the mixed forest association and beneath this the ground has been cleared and maintained in a state of low growth. It has species found in meadow and alder associations together with some not found elsewhere on the island including *Typha latifolia, Drosera rotundifolia, Hypericum canadense* and *Spiraea latifolia*.

25) Alder Thicket. Alder thickets on Pendleton Island occupy former cleared areas, particularly at the NE end where fire has not been such a modifying influence. This association is strongly dominated by *Alnus viridis* ssp. *crispa*. The thicket flora is sparse but in wetter locations, *Iris versicolor, Scirpus microcarpus, Juncus filiformis, Polygonum sagittatum, Lycopus uniflorus* and *Viola obliqua* occur. In areas where the alders thin into small clearings, the herb flora is composed mainly of *Aster novi-belgii, Carex silicea, Rosa blanda, Thalictrum pubescens, Solidago uliginosa, Dichanthelium boreale* and *Juncus effusus*.

26) Open Headland. The SW tip of Pendleton Island is characterized by thin soil, abundant, small, rocky outcrops and generally exposed conditions. It may never have been completely forested, but grazing and burning have probably been the main influences shaping the present vegetation. This shows some floristic affinities to the

meadow associations that follow, but differs in many respects. The area is generally dominated by heath plants, including *V. angustifolium, V. myrtilloides, V. vitis-idaea* with associated *Cornus canadense* and *Epilobium angustifolium* (absent from oldfield associations [#27 and #28]). The following species were frequent, but never dominant: *Festuca rubra, Danthonia spicata, Hieracium pilosella, Hypericum perforatum* and *Rosa carolina.*

27) Oldfield Association I. At least part of this area was once cultivated and used for crops. Most of the area, however, was probably used for grazing. Evidence of its former use may be seen in a patch of rhubarb *Rheum raponticum*, as well as in old fences and foundations. The principal flowering plants are *Festuca rubra, Hypericum perforatum, Hieracium pilosella* and *Rosa carolina*. Frequent associates are *Anaphalis margaritacea, Linaria vulgaris, Oenothera biennis* and *Danthonia spicata*. In the shadow of the forest are large patches of raspberry, *Rubus strigosus*. This successional sere has been maintained by seasonal burning.

28) Oldfield Association II. This area, once part of the main grazing meadow, lies in an area of poor drainage and has different species from the main meadow [association #27)]. The dominant species are *Onoclea sensibilis, Solidago canadensis, Senecio schweinitzianus, Cirsium arvense, Aster umbellatus* and *A. puniceus*.

There is one further semi-terrestrial association, which has been included on the map under littoral association #4, flowering plants. This is the flora of the crest of the gravel beach-bar on the NW coast of the island. The biota of this bar shows many affinities with salt marshes and similarities to beach top associations around Pendleton Island. In several respects, however, it is unique. The crest of the beach is dominated by a mixed association of *Bidens frondosa, Lathyrus japonicus* and *Galeopsis tetrahit* which does not occur elsewhere on the island. Behind the bar the association grades into a sparse salt-marsh flora colonised by plants such as *Suaeda maritima, Salicornia europaea, Atriplex patula, Limonium carolinianum* and *Puccinellia americana.*

Table 1 presents a list of all species found on Pendleton Island during this study. Species are listed in taxonomic order and the associations in which they occur are shown.

DISCUSSION

When this project was started we intended to map communities in the classic sense, which would have produced a map with no overlap among the associations shown. When the data were reviewed, however, this was seen to be an impractical approach that would not yield the most useful information. The reason for this is that the majority of hard bottom communities in this area result from the intense grazing activities of the green sea urchin *Strongylocentotus droebachiensis*. The capacity of this species to modify the marine benthic community structure has been extensively discussed in the

literature; papers useful in helping to interpret the local situation being Paine and Vadas 1969, Mann and Breen 1972, Breen and Mann 1976a and b, Ebert 1977, Mann 1977, Breen 1980, Himmelman 1980, Hooper 1980, Pringle *et al.* 1980, and Chapman 1981. Although there is evidence that destructive grazing by *S. droebachiensis* spread up the coastline of Nova Scotia starting in 1968 (Pringle *et al.* 1980), there is none to suggest that the Western Isles area was part of this process. As far as is known, the community resembling the so-called 'urchin barren grounds' of Nova Scotia have existed here for a long time. It is curious that after the initial destruction of kelp beds, the populations of urchins remain high, since an abundant food source is gone (Breen 1980, Logan *et. al.* 1984) and there has been considerable speculation concerning the inevitable shift in diet (Mann 1977, Douglas 1976). Although some food may arrive as drift of dislodged littoral algae, the bulk of the food must be from growth within the association. Over time the continued grazing pressure by urchins results in an increase in the percentage cover of crustose coralline algae (Sousa *et al.*1981), while the closely associated *Mastocarpus stellatus* (tetrasporophyte) remains stable (Paine *et al.* 1979). There is therefore an overall increase in the cover of crustose algae in the face of urchin grazing. The literature suggests that the diversity within the crustose coralline algae-urchin association is low. However, the results of this study, combined with others in the area, suggest that while diversity per unit area is indeed low, total diversity is very high. The ability to cover a very large area of bottom with video surveys has a great advantage over small plot methods when looking at such phenomena. To emphasise the areal cover, longevity and importance of *S. droebachiensis* and crustose coralline algae, these two components have been mapped overlying other associations on the map.

Probably one of the most interesting features of the Pendleton Island area is the presence of a great diversity of tidal current conditions in a comparatively small area, giving an excellent opportunity to observe their effects. This is especially true, considering that urchins decline in numbers as maximum current velocities increase. Presumably, their globular shape creates turbulence and fosters dislodgement. The general increase in macro-algae in high current areas (> 40 cm sec^{-1}) can probably be attributed to the low sea urchin densities, but it is interesting to note that it is not *Laminaria* species that appear, but *Agarum cribrosum*. Kitching (1987) also found that *Laminaria saccharina* in Loch Hyne in Ireland was absent in areas of the fastest current but dominant in areas of reduced but still strong current, where populations of the local urchin, *Paracentrotus lividus*, were reduced. Why *L. saccharina* does not dominate moderate current situations in the Quoddy region is not known but it may be that the smaller urchin here is able to exist at higher current velocities than its larger counterparts elsewhere. Around Pendleton Island, areas of declining current, where Little Letite Passage and Pendleton Passage open out, are occupied by a variety of associations including #13, red algae, #22, *Cucumaria frondosa* and #23, ascidians. These areas appear to be part of the suite of associations modified by *S. droebachiensis,* since long-lived algae are absent, but in which the urchins are only periodically present, giving opportunities for some algae and sessile organisms such as ascidians to settle and develop. It is assumed that, once established, the ascidians *B. ovifera* and *H. pyriformis* are able to tolerate urchin grazing.

The sea cucumber, *C. frondosa*, seems able to exist in very high numbers in areas of moderate current. In video records of such areas, the bottom is frequently obscured by the bodies and tentacles of this species.

The hard-bottom associations dominated by animals in the Pendleton Island area are mostly characterised by filter feeders. These include #8, *Mytilus edulis* in the intertidal and subtidal, #9, *Semibalanus balanoides* in the intertidal, #15, *Myxicola infundibulum*, #17, *Mya arenaria*, #18, *M. modiolus*, #22, *C. frondosa* and #23, ascidians all in the subtidal. Most of these are active filter feeders but two, *M. infundibulum* and *C. frondosa* are passive filter feeders. In many of these associations, the abundance and biomass of the dominant forms is extraordinarily high. Conditions that allow this magnitude of development of filter feeders must include a good supply of suspended organic material for food. Although the Quoddy region has reasonably high primary productivity (Prouse *et al.* 1984), it is not exceptionally productive and quantities of suspended organic materials per unit volume are often low (Gardner and Thomas 1987). It is therefore a combination of reasonable suspended food supplies and high tidal currents that gives the high total food supply. The correlation of high populations of filter feeding organisms with areas of high and moderate currents also gives evidence for this. In some of these populations, for example the intertidal *M. edulis* beds in Pendleton Passage, population densities up to over 3000 m^{-2} occur, but the individual mussels never reach a large size and growth is slow. In such situations, despite the rapid currents, food supply is probably limiting.

The floras of several islands in the outer Bay of Fundy are now relatively well documented (Weatherby and Adams 1945, Pike and Hodgdon 1963, McCain *et al.* 1973, McCain 1975). Based on a compilation of these earlier studies and on her inventory of the Pendleton flora, McAslan (1989) was able to demonstrate an approximately linear relationship between the logarithm of island area and the logarithm of species diversity. Such a pattern is in keeping with the predictions of MacArthur and Wilson's (1967) equilibrium theory on the diversity of island biotas. Of all the Bay of Fundy islands that have been described, Pendleton is most similar to Kent Island off Grand Manan (McCain 1975). They are about the same size (117 and 95 ha, respectively) and are floristically very similar, the slightly larger number of species recorded for Kent Island (240 *vs.* 210 on Pendleton Island) being attributable to the intensity of exploration. Since Kent Island is much further from the mainland than Pendleton Island, it might be expected that it would have been colonized by fewer species. However, it lies close to Grand Manan, which has 582 species (Weatherby and Adams 1945). An analogous relationship probably exists between the floras of Deer Island and Pendleton Island.

LITERATURE CITED

Breen P.A. 1980. Relations among lobster, sea urchins and kelp in Nova Scotia. pp. 24-32. In. Pringle J.D., G.J. Sharp and J.F. Caddy [Eds.]. Proc. Workshop on the Relations Between Sea Urchin Grazing and Commercial Plant/Animal Harvesting. Can. Tech. Rept. Fish. Aquat. Sci. # 954.

Breen P.A. and K.H. Mann. 1976a. Destructive grazing of kelp by sea urchins in eastern Canada. J. Fish. Res. Bd. Can. 33: 1278-1283.

Breen P.A. and K.H. Mann 1976b. Changing lobster abundance and the destruction of kelp beds by sea urchins. Mar. Biol. 34: 137-142.

Chapman A.R.O. 1981. Stability of sea urchin dominated barren grounds following destructive grazing of kelp in St. Margarets Bay, eastern Canada. Mar. Biol. 62: 307-311.

Christie D.S. 1983. Birds. Ch. 14, pp 215-229. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Cook R.H. 1988. Salmon aquaculture in the Bay of Fundy: a quiet success. Bull. Aquacult. Assoc. Can. 88:28-40.

Corey S. 1983. Larger zooplankton of the Quoddy Region. Ch. 12. pp 193-200. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p

Douglas C.A. 1976. Availability of drift materials and the covering response of the sea urchin, *Strongylocentrotus purpuratus* (Stimpson). Pac. Sci. 30: 83-89.

Ebert T.A. 1977. An experimental analysis of sea urchin dynamics and community interactions on a rock jetty. J. Exp. Mar. Biol. Ecol. 27: 1-22.

Gardner J.P.A. and M.L.H. Thomas. 1987. Growth, mortality and production of organic matter by a rocky intertidal population of *Mytilus edulis* in the Quoddy Region of the Bay of Fundy. Mar. Ecol. Prog. Ser. 39: 31-36.

Gaskin D.E. 1983. The marine mammal community. Ch. 19, pp 245-268. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Gorham S.W. and J.S. Bleakney. 1982. Amphibians and reptiles. Ch. 15, pp 230-244. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Himmelman J.H. 1980. The role of the green sea urchin, *Strongylocentrotus droebachiensis*, in Newfoundland waters. pp. 92-119. In. Pringle J.D., G.J. Sharp and J.F. Caddy [Eds.]. Proc. Workshop on the Relations Between Sea Urchin Grazing and Commercial Plant/Animal Harvesting. Can. Tech. Rept. Fish. Aquat. Sci. # 954.

Hinds H. 1983. The coastal forest of the Passamaquoddy Bay area. Ch. 17. pp 269-276. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Hooper R.G. 1980. Observations on algal-grazer interactions in Newfoundland and Labrador. pp. 120-124. In. Pringle J.D., G.J. Sharp and J.F. Caddy [Eds.]. Proc. Workshop on the Relations Between Sea Urchin Grazing and Commercial Plant/Animal Harvesting. Can. Tech. Rept. Fish. Aquat. Sci. # 954.

Kitching J.A. 1987. Ecological studies at Lough Hyne. Adv. Ecol. Res. 17: 115-186.

Lakshminarayana J.S.S. 1983. Phytoplankton of the Quoddy Region. Ch. 11, pp 176-192. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Logan A. 1988. A subtidal hard substrate epibenthic community below 30m in Head Harbour Passage, New Brunswick, Canada. Estuar. Coast. and Shelf Sci. 27:445-459.

Logan A., A.W. McKay and J.P.A. Noble. 1983. Sublittoral hard substrates. Ch. 8, pp 119-139. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Logan A., F. H. Page and M.L.H. Thomas. 1984. Depth zonation of epibenthos on sublittoral hard substrates of Deer Island, Bay of Fundy, Canada. Estuar. Coast. and Shelf Sci. 18: 571-592.

Loucks O.L. 1960. A forest classification for the Maritime Provinces. Proc. N.S. Inst. Sci. 25: 85-167.

MacArthur R.H. and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press. 191p.

Mann K.H. 1977. Destruction of kelp beds by sea urchins: A cyclical phenomenon or irreversible degradation? Helgolander. wiss. Meeresunters. 30: 455-467.

Mann K.H. and P.A. Breen. 1972. The relations between lobster abundance, sea urchins and kelp beds. J. Fish. Res. Bd. Can. 29: 603-609.

MacKay A.A. 1965. A zoogeographical study of the vertebrate fauna of the Grand Manan Archipelago, New Brunswick. Maritime Biological Labs., St. Stephen, N.B. Unpaginated.

McAslan A.A. 1989. A floristic survey of Pendleton Island. B.Sc. Thesis, University of New Brunswick. 81p.

McCain J.W. 1975. A vegetational survey of the vascular plants of Kent Island group, Grand Manan, New Brunswick. Rhodora 77: 196-210.

McCain J.W., R.B. Pike and A.R. Hodgdon. 1973. The vascular flora of Kent Island, Grand Manan, New Brunswick. Rhodora 75: 311-322.

Paine R.T. and R.I. Vadas. 1969. the effects of grazing by sea urchins, *Strongylocentrotus* spp., on benthic algal populations. Limn. Oceanogr. 14:710-719.

Paine R.T., C.J. Slocum and D.O. Duggins. 1979. Growth and longevity of the crustose red alga *Petrocelis middendorfi*. Mar. Biol. 51: 185-192.

Patel I.M., B. J. Hunter and L.D. McCavour. 1987. Geological map of Pendleton Island. Dept. of Geology, Univ. N.B. 1 sheet. [Unpublished.]

Pike R.B. and A.R. Hogdon. 1963. The flora of the Wolf Islands, New Brunswick. Part 1. Rhodora 65: 82-97.

Pringle J.D., G.J. Sharp and J.F. Caddy. 1980. [Eds.]. Proc. Workshop on the Relations Between Sea Urchin Grazing and Commercial Plant/Animal Harvesting. Can. Tech. Rept. Fish. Aquat. Sci .# 954.

Prouse N.J., D.C. Gordon Jr., B.T. Hargrave, C.T. Bird, J. McLachlan, J.S.S. Lakshminarayana, J. Sita-Devi and M.L.H. Thomas. 1984. Primary production: organic matter supply to the ecosystems in the Bay of Fundy. In. Gordon D.C. Jr. and M.J. Dadswell [Eds.] Update of the Marine Environmental Consequences of Tidal Power Development in the Upper Reaches of the Bay of Fundy. Can. Tech. Rept. Fish. and Aquat. Sci. #1256.

Rayburn A. 1975. Geographical names of New Brunswick. Canada Dept. Energy, Mines and Res., Can. Perm. Comm. on Names, Toponymy Study #2. Ottawa 304p.

Raymond W.O. 1892. Glimpses of the past XLVII. The Passamaquoddy Indians and the revolutionary war. Saint John Courier, Dec. 20, 1892, pp 40-41.

Raymond W.O. 1893. Glimpses of the past L. Events of the war . Saint John Courier, Jan. 12, 1893. pp 42-43.

Roff J.W. 1983. Microzooplankton of the Quoddy Region. Ch. 13, pp 201-214. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Rowe J.S. 1972. Forest regions of Canada. Dep. Fish. and Environ. Can. For. Serv. Publ. # 1300, 172p.

Scott W.B. 1983. Fishes. Ch. 10, pp 156-175. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Sousa W.P., S.C. Schroeter and S.D. Gaines. 1981. Latitudinal variation in intertidal algal community structure: the influence of grazing and vegetative propagation. Oecol. (Berl.) 48: 297-307.

South G.R. and I. Tittley. 1986. A checklist and distributional index of the benthic marine algae of the North Atlantic Ocean. Joint Publ. Huntsman Marine Lab., St. Andrews, New Brunswick and Brit. Mus. Nat. Hist. 76p.

Steele D. H. 1983. Coarse sedimentary shores. Ch. 5, pp 74-94. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Thomas M.L.H. 1983. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Thomas M.L.H. 1983a. Meteorology. Ch. 2, pp 5-8. In. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Thomas M.L.H. 1989. Introducing the sea. 4th Ed. Huntsman Mar. Sc. Cent., St. Andrews, N.B. 112p.

Thomas M.L.H. 1990. Littoral communities and zonation on rocky shores in the Bay of Fundy, Canada, an area of high tidal range. Biol. J. Linn. Sc. *In press.*

Thomas M.L.H., D.C. Arnold and A.R.A. Taylor. 1983. Rocky intertidal communities. Ch. 4, pp 35-73. **In**. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Trites R. W. and C.J.R. Garrett. 1983. Physical oceanography of the Quoddy Region. Ch. 3, pp 9-34. **In**. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Weatherby C.A. and J. Adams. 1945. A list of the vascular plants of Grand Manan, Charlotte Co., N.B. The Gray Herbarium, Harvard Univ, Cambridge, Mass. U.S.A. #CLVIII. 96p.

Wicklund R.E. and K.K. Langmaid. 1953. Soil survey of southern New Brunswick. Fourth report of the New Brunswick Soil Survey, Fredericton, N.B. 182p.

Wilder D.G., P.F. Elson, D.E. Gaskin, A.C. Kohler, W.T. Stobo and S.N.Tibbo. 1974. Renewable marine resources. Section 3. 105-139. **In.** Anon, 1974. Summary of socio-economic and other factors relevant to oil spills in the Passamaquoddy Region of the Bay of Fundy. Fish. Res. Bd. Can., Tech. Rept. # 428, 229p.

Wildish D.J. 1983. Sublittoral sedimentary substrates. Ch. 9, pp 140-155. **In**. Thomas M.L.H. [Ed.] Marine and Coastal Systems of the Quoddy Region, New Brunswick. Can. Spec. Publ. Fish. and Aquat. Sci. 64: 306p.

Table 1. Species collected or observed in shallow marine, littoral and terrestrial plant associations of Pendleton Island.

SPECIES	ASSOCIATION	SPECIES	ASSOCIATION
CHRYSOPHYTA			
Colonial Diatoms	6,7,8,9		
CHLOROPHYTA[2]			
Chaetomorpha melagonium	6	*Prasiola stipitata*	2
Cladophora sp.	5,6,8	*Spongomorpha arcta*	5,6,8
Enteromorpha intestinalis	5,6,8,9	*Ulothrix flacca*	2,5,6
Monostroma sp.	5,6,8,9	*Ulva lactuca*	5,6,8,9
PHAEOPHYTA			
Agarum cribrosum	10,14,22,23	*Fucus edentatus*	6
Alaria esculenta	6,14,22,23	*Fucus evanescens*	6
Ascophyllum nodosum	6	*Fucus spiralis*	6
Chordaria flagelliformis	6	*Fucus vesiculosus*	6
Chorda tomentosa	11	*Laminaria saccharina*	6,14,22,23
Desmarestia viridis	10,12,13,14,20,22,23	*Petalonia fascia*	6
Ectocarpus siliculosus	6,7,8,9	*Pilayella littoralis*	6,7,9
Elachista fucicola	6	*Scytosiphon lomentaria*	6
RHODOPHYTA			
Audouinella purpurea	6	Crustose coralline algae	6,10,12,13,14,18,20, 22,23
Ceramium sp.	10,13,14,22,23	*Devaleraea ramentaceum*	6
Chondrus crispus	6	*Dumontia contorta*	6
Corallina officinalis	6	*Hildenbrandia rubra*	6,12

Mastocarpus stellatus	6	*Polysiphonia lanosa*	6
Palmaria palmata	6,13,22,23	*Polysiphonia urceolata*	13,14,22,23
'Petrocelis middendorfii'[1]	6,12,13,14	*Porphyra umbilicalis*	6,13,14,22,23
Phycodrys rubens	10,12,13,14,20,21,23	*Ptilota serrata*	13,14,22,23

LICHENS

Acarospora molybdina	3	*Phaeophyscia sciastra*	3
Arthonia phaeobaea	3	*Rhizocarpon grande*	3
Caloplaca microthallina	3	*Rhizocarpon obscuratum*	3
Caloplaca scopularis	3	*Verrucaria ceuthocarpa*	2,3
Caloplaca verruculifera	3,24	*Verrucaria halizoa*	6
Lecanora contractula	3	*Verrucaria maura*	2
Lecanora polytropa	3	*Verrucaria mucosa*	6
Lepraria cf. *finkii*	3	*Xanthoparmelia conspersa*	3
Parmelia saxatilis	3	*X. cumberlandia*	3
Parmelia sulcata	3	*Xanthoria elegans*	3

BRYOPHYTA

Bryum salinum	4

EQUISETOPHYTA

Equisetum arvense	4,25

LYCOPODIOPHYTA

Lycopodium annotinum	24	*Lycopodium complanatum*	24
Lycopodium clavatum	24	*Lycopodium obscurum*	24

POLYPODIOPHYTA

Cystopteris fragilis	24
Dennstaedtia punctilobula	24
Dryopteris campyloptera	24
Dryopteris intermedia	24
Dryopteris carthusiana	24
Gymnocarpium dryopteris	24
Onoclea sensibilis	24,25
Osmunda claytoniana	24
Polypodium virginianum	24
Thelypteris phegopteris	24

PINOPHYTA

Abies balsamea	24
Juniperus communis	4,26
Juniperus horizontalis	4,26
Larix laricina	24
Picea glauca	24
Picea mariana	24
Picea rubens	24
Thuja occidentalis	24

MAGNOLIOPHYTA

Acer pensylvanicum	24
Acer rubrum	24
Acer spicatum	24
Achillea millefolium	4,26,27
Actaea rubra	24
Agropyron repens	27
Agropyron tracnycaulum	4
Agrostis capillaris	26,27
Agrostis gigantea	27
Agrostis scabra	26,27
Agrostis stolonifera	27
Alopecurus pratensis	26,27
Alnus viridis ssp. *crispa*	25
Ammophila breviligulata	4
Anaphalis margaritacea	27
Angelica lucida	4
Antennaria neglecta	27
Anthoxanthum odoratum	26,27

Apocynum androsaemifolium	26
Aralia hispida	24,25
Aralia nudicaulis	24
Aster acuminatus	24,25
Aster cordifolius	24,28
Aster lateriflorus	25
Aster novi-belgii	4,25
Aster puniceus	4,28
Aster umbellatus	24
Atriplex acadiensis	4
Atriplex glabriuscula	4
Atriplex patula	4
Betula cordifolia	24
Betula alleghaniensis	24
Betula papyrifera	24
Betula x caerulea	24
Bidens frondosa	4
Cakile edentula	4
Calystegia sepium	4
Campanula rotundifolia	4,26
Carex arctata	4,24
Carex brunnescens	4,24
Carex canescens	4,24
Carex capillaris	4
Carex communis	4,24
Carex crinita	4,27
Carex deflexa	24
Carex flava	4,27
Carex gracillima	24
Carex gynandra	24
Carex leptonervia	24
Carex novae-angliae	24
Carex pallescens	27
Carex silicea	4
Carex stipata	4
Carex vesicaria	4,27
Carum carvi	27
Cerastium fontanum	24
Chenopodium album	4
Circaea alpina	24
Cirsium arvense	4,28
Clintonia borealis	4,24
Coptis trifolia	24
Cornus canadensis	24,26
Cotula coronopifolia	4
Danthonia spicata	27
Deschampsia flexuosa	4,24,26,27
Dichanthelium boreale	24
Diervilla lonicera	4,26,27
Drosera rotundifolia	24
Elymus mollis	4

Empetrum nigrum	4,26
Epilobium angustifolium	26
Epilobium ciliatum	26
Epilobium palustre	26
Erigeron strigosus	26,27
Euphrasia americana	26,27
Fagopyrum tataricum	24
Fagus grandifolia	24
Festuca rubra	26,27
Festuca tenuifolia	26,27
Fragaria virginiana	24,26,27
Galeopsis tetrahit	4,24
Galium palustre	4,26,27
Glyceria canadensis	24,27
Glyceria striata	24,27
Hedyotis caerulea	27
Hieracium aurantiacum	24,26
Hieracium caespitosus	24,26,27
Hieracium pilosella	26,27
Hypericum canadense	4,24
Hypericum perforatum	24,26,27
Impatiens capensis	25
Iris versicolor	24,25
Juncus balticus	27
Juncus bufonius	4
Juncus effusus	25,27
Juncus filiformis	4
Juncus gerardii	4
Lathyrus japonicus	4
Lathyrus pratensis	4
Leontodon autumnalis	4
Leucanthemum vulgare	4,24,26,27
Ligusticum scothicum	4
Limonium carolinianum	4
Linaria canadensis	4,26
Linaria vulgaris	26,27
Linnaea borealis	24
Lonicera villosa	24
Luzula multiflora	24,26,27
Lycopus americanus	25
Lycopus uniflorus	24,25
Maianthemum canadense	24
Malus sylvestris	27
Mentha sp.	27
Moehringia lateriflora	24
Moneses uniflora	24
Monotropa uniflora	24
Myrica gale	24,25
Oenothera biennis	27
Oenothera perennis	26,27,28
Oxalis montana	24
Oxalis stricta	26,27
Plantago maritima	4

Platanthera lacera	26,27
Poa compressa	26,27
Poa palustris	26,27
Poa pratensis	26,27
Polygonum sagittatum	25,27
Populus grandidentata	24
Populus tremuloides	24
Potentilla anserina	26,27
Potentilla argentea	27
Potentilla simplex	26,27
Potentilla tridentata	26,27
Prenanthes altissima	4
Prunella vulgaris	4,24
Prunus pensylvanica	25
Prunus virginiana	24,25
Puccinellia americana	4
Pyrola elliptica	24
Ranunculus acris	26,27
Raphanus raphanistrum	4
Rheum raponticum	27
Rhinanthus minor	27
Rhododendron canadense	25
Ribes hirtellum	4,26
Rosa blanda	4,27
Rosa carolina	4,26,27
Rosa rugosa	4
Rubus pubescens	24
Rubus strigosus	24
Rudbeckia hirta	26,27
Rumex acetosella	26,27
Rumex salicifolius	4
Sagina procumbens	4
Salicornia europaea	4
Salix fragilis	24
Sambucus canadensis	24
Sambucus racemosa	24
Scirpus microcarpus	25
Scutellaria galericulata	24,27
Sedum rosea	4
Senecio schweinitzianus	26,27,28
Senecio sylvaticus	26,27
Sisyrinchium montanum	26,27
Solanum dulcamara	24
Solidago bicolor	24,26,27
Solidago canadensis	26,27
Solidago puberula	4
Solidago rugosa	4,27
Solidago sempervirens	4
Sorbus americana	4,24
Spergularia marina	4
Spiraea latifolia	24

Stellaria graminea	26,27	*Typha latifolia*	25
Stellaria media	4	*Vaccinium angustifolium*	26
Suaeda maritima	4	*Vaccinium myrtilloides*	26,27
Thalictrum pubescens	25	*Vaccinium vitis-idaea*	24,26,27
Triadenum fraseri	25	*Verbascum thapsus*	26,27
Trientalis borealis	24	*Veronica officinalis*	26,27
Trifolium arvense	26,27	*Veronica serpyllifolia*	26,27
Trifolium campestre	26,27	*Vicia cracca*	26
Trifolium pratense	26	*Viola adunca*	24
Trifolium repens	24	*Viola incognita*	24
Tussilago farfara	24	*Viola macloskeyi*	24
		Viola obliqua	24,25

PORIFERA

Halichondria bowerbanki	14,22,23	*Haliclona loosanoffi*	14,22,23
Halichondria panicea	6,14,22,23	*Haliclona oculata*	14,22,23

COELENTERATA

Antennularia sp.	14,22,23	*Obelia* sp.	14,22,23
Campanularia amphora	6	*Sertularia pumila*	6
Gersemia rubiformis	14	*Tealia felina*	6,10,14,22,23
Metridium senile	6,10,14,22,23	*Tubularia* sp.	14,22,23

BRYOZOA

Flustrellidra hispida	6

NEMERTEA

Cerebratulus lacteus	6	*Lineus ruber*	6,8

ANNELIDA

Amphitrite johnstoni	14,15,17	*Nephtys bucera*	15,17
Clitellio arenarius	6	*Nephtys incisa*	15,17
Enchytraeus albidus	6	*Nereis virens*	15,17
Fabricia sabella	6	*Peloscolex benedeni*	6
Glycera americana	15,17	*Spirorbis borealis*	6,14,22,23
Myxicola infundibulum	14,15	*Spirorbis spirillum*	6,14,22,23

AMPHINEURA

Lepidopleurus cancellatus	14,22,23	*Tonicella rubra*	14,22,23
Tonicella marmorea	14,22,23		

GASTROPODA

Acanthodoris pilosa	14,22,23	*Littorina obtusata*	6
Aeolidia papillosa	14,22,23	*Littorina saxatilis*	2,6
Buccinum undatum	6,10,14,22,23	*Lunatia heros*	8
Colisella testudinalis	6,8,16,14,22,23	*Lunatia triseriata*	8
Coryphella sp.	14,22,23	*Margarites helicinus*	6
Crepidula fornicata	10,13	*Neptunea decemcostata*	10,14,22,23
Dendronotus frondosus	6,14,22,23	*Nucella lapillus*	6,8,9
Lacuna vincta	6	*Onchidoris* sp.	14,22,23
Littorina littorea	5,6,7,8,16	*Skeneopsis planorbis*	6

BIVALVIA

Anomia simplex	14,22,23	*Mya arenaria*	15,17,21
Chlamys islandicus	17,20,21	*Mytilus edulis*	5,6,7,8,14,22,23
Hiatella arctica	14,22,23	*Placopecten magellanicus*	17,20,21
Modiolus modiolus	10,12,13,14,18,20,22, 23		

CRUSTACEA

Balanus balanus	14	*Homarus americanus*	14,22,23
Balanus crenatus	6	*Hyas* sp.	14,22,23
Cancer sp.	14,22,23	*Jaera marina*	5,6
Carcinus maenas	6,8,14,22,23	*Pagurus* sp.	13,14,22,23
Crangon septemspinosa	6,15,17,21	*Pandalus montagui*	14,22,23
Gammarus oceanicus	2,5,6,7,8,9	*Semibalanus balanoides*	5,6,8,9

ECHINODERMATA

Asterias forbesii	6,10,14,22,23	*Leptasterias littoralis*	6
Asterias vulgaris	6,10,14,22,23	*Psolus fabricii*	14,22,23
Chiridota laevis	8	*Solaster endeca*	10,12,13,14,18,20,22, 23
Cucumaria frondosa	10,12,13,14,18,20,22, 23	*Solaster papposus*	10,12,13,14,18,20,22, 23
Echinarachnius parma	20,21	*Strongylocentrotus droebachiensis*	All sublittoral
Henricia sanguinolenta	10,14,22,23		

ASCIDIACEA

Aplidium pallidum	14,22,23	*Dendrodoa carnea*	14,22,23
Boltenia echinata	10,14,22,23	*Didemnum albidum*	10,14,22,23
Boltenia ovifera	10,14,22,23	*Halocynthia pyriformis*	10,12,13,14,20,22,23

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[1] '*Petrocelis middendorfii*' = tetrasporophyte of *Mastocarpus stellatus*.

[2] Algal names according to South and Tittley (1986).

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